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TAXONOMIC CHARTS OF THE MONOCOTYLEDONS AND THE DICOTYLEDONS.

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At various times botanists have constructed phylogenetic diagrams to show the evolutionary relationship of the various families of plants, but in all of these family trees the attempt has been made to represent the actual evolutionary history of each plant group. Beyond representing the general lines of evolution of the vegetable kingdom, these diagrams, it seems to the writer, do not go. Haeckel in his "Phylogenie der Protisten und Pflanzen" gives elaborate tables to represent the phylogeny of different plant groups, Campbell in his lectures on the "Evolution of Plants" (1899) gives at the close of each important section of his book family trees of the algæ, fungi, mosses, ferns and flowering plants. Bessey[1] in 1897 discussed before the Botanical Society of America the phylogeny and taxonomy of the angiosperms, while Engler in *The Botanical Gazette* in May, 1898 (pp. 338–352), discusses the taxonomic division of the spermatophytes, as an abridged treatment of the same subject in Parts II., III. and IV. of the supplement to his "Die natürlichen Pflanzenfamilien." Bonnier and Sablon give useful

[1] Bessey, Charles E., "The Phylogeny and Taxonomy of Angiosperms," *Botanical Gazette*, XXIV (1897).

tables of taxonomic relationships in their large text-book of botany ("Cours de Botanique Phanerogames").

Bearing upon this same field of botanical speculation and investigation, a number of important papers have appeared which approach the subject from the morphologic and histologic sides. Curtis in his "Text-Book of General Botany" (1897) conjectures the nature of the affinities of monocotyledons and dicotyledons, stating that the monocotyledons may be considered as a branch that has departed from the dicotyledonous type and become structurally weak owing to their aquatic habitat. He also gives a short statement of the evolution of the flower and of floral types. One of the most interesting theories regarding the evolution of the higher flowering plants is one proposed by Balfour[1] on the philosophy of water and vegetation. In this paper, Balfour traces the evolution of the types which being exposed to the failure of water show consequential difficult movement of the sperm cells and, therefore, have adapted themselves gradually to a dry environment by the development of flowers and true seeds. Campbell[2] describes the causes that led to the general abandonment of the aquatic habit and the adoption of a land habit, which characterizes the predominant plants of the present time. The adoption of the seed habit, according to Scott,[3] gives the plant possessing such a habit the following advantages:

1. Pollination on the parent plant, and consequently greater certainty in bringing together the two kinds of spores.

2. Fertilization either on the plant or at least within the sporangium giving greater certainty of success and protection at the critical moment.

3. Protection of the young prothallus from external dangers.

Rendle in the *New Phytologist* (II: 66, 1903) considers the origin of the perianth in seed plants, and later in 1904 in his book the "Classification of Flowering Plants" traces the affinities of the

[1] Balfour, Prof. I. Bayley, "Philosophy of Water and Vegetation, *Nature,* 64: 557, October 3, 1901.

[2] Campbell, D. H., "The Origin of Terrestrial Plants," *Science,* n. s., XVII: 93, 1903.

[3] Scott, D. H., "Origin of the Seed Habit," *Nature,* 68: 377–382, 1903.

gymnosperms and the monocotyledons in a clear and lucid manner. Ethel Sargant[1] from detailed macroscopic and microscopic studies of a large number of seeds and seedlings describes the dicotyledonous seedlings that show a well-marked cotyledonary tube, thus suggesting the origin of monocotyledons from a dicotyledonous stock. She gives a complete bibliography of the more important articles that have recently appeared on the subject, mentioning the work of Lyon on the embryogeny of *Nelumbo* and Holm on *Podophyllum peltatum* and *Erigenia bulbosa.* Harris[2] in a short article gives a brief, but useful, resumé of the attitude of modern botanists on the origin of monocotyledons from dicotyledons. Coulter and Chamberlain believe that the phylogeny of the angiosperms will always remain a baffling problem. They believe that there is not sufficient evidence of the monophyletic origin of monocotyledons and dicotyledons as claimed by Jeffrey, Queva, Sargant and others. They believe that the facts are strongly in favor of an independent origin of both monocotyledons and dicotyledons.

Having briefly reviewed the current theories concerning the origin and taxonomy of the angiosperms, it falls to the lot of the writer to describe the taxonomic charts which accompany this account. In the arrangement of the dicotyledonous and the monocotyledonous families, the plan has been adopted of showing the generally recognized affinities of the different groups, rather than absolutely relying on the proven natural descent, or evolutionary relationship. Wherever that descent has been established definitely by botanical investigation, it has been incorporated in the accompanying charts. Absolute affinity is an extremely difficult matter to determine in families of such widely diversified structure. It is important, however, to have some phylogenetic scheme which will picture in a diagrammatic way the supposed relationship of the numerous plant families. Such diagrams, the author believes, will greatly assist in the future investigation of the morphology, embryology and phylogeny of the flowering plants.

[1] Sargant, Ethel, "Theory of the Origin of Monocotyledons founded on the Structure of their Seedlings," *Annals of Botany,* XVII: 1–92, Jan., 1903.

[2] Harris, J. Arthur, "Monocotyledons or Dicotyledons," *The Plant World,* VI: 79, Apr., 1903.

In the preparation of the two original charts illustrating the taxonomy of the monocotyledons and dicotyledons, the author has been greatly assisted by Engler and Prantl's "Die natürlichen Pflanzenfamilien," Englers' "Syllabus der Pflanzenfamilien"

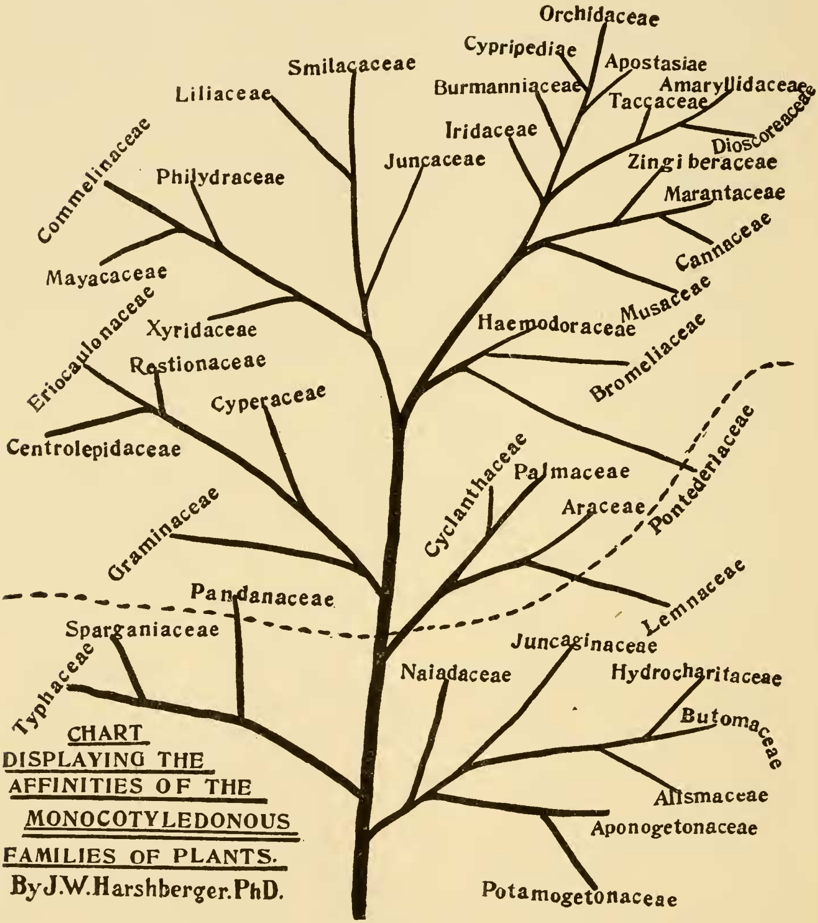


FIG. 1.

(1898), Warming's "Systematic Botany," Le Maout and Decaisne's "General System of Botany" (Mrs. Hooker's translation), Lindley's "Vegetable Kingdom" and Rendle's "Classification of Flowering Plants" (Volume I.).

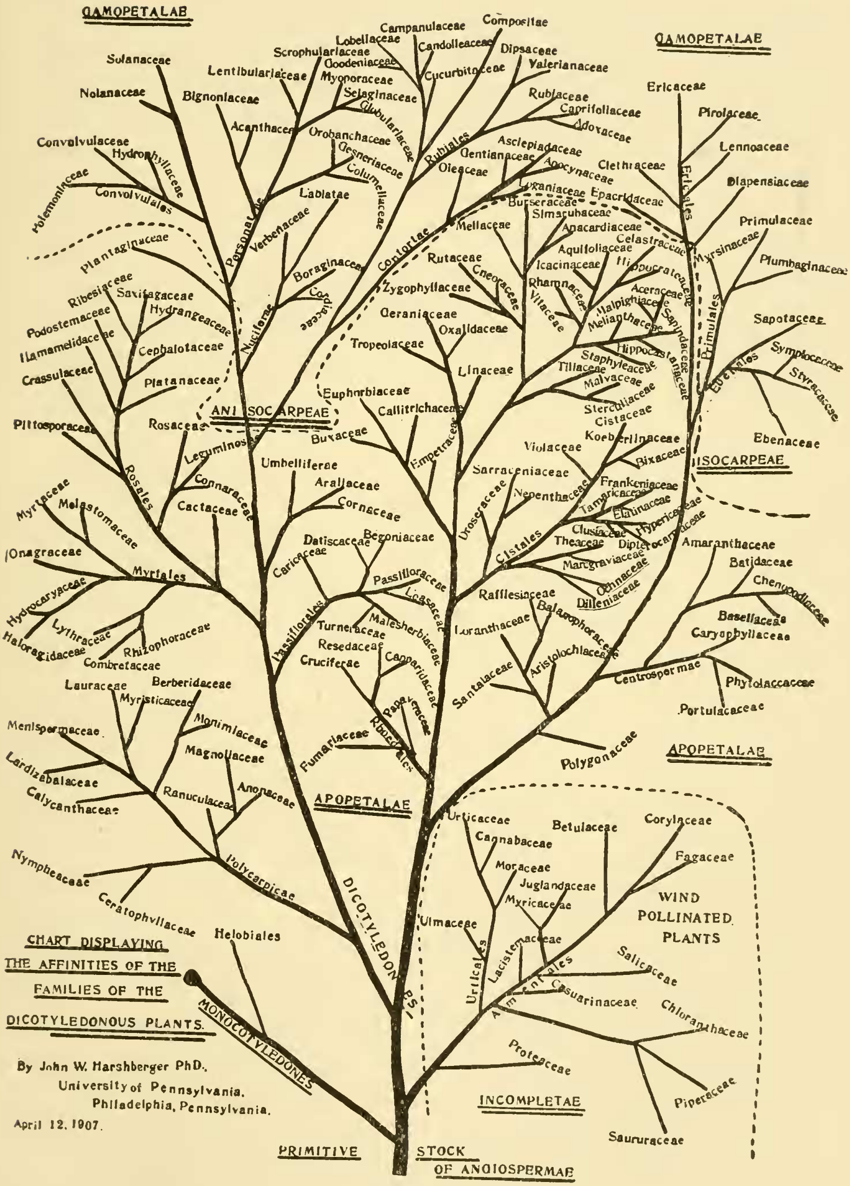
Referring to the chart illustrating the taxonomy of the monocotyledons, the families may be divided roughly into two groups, the aquatic and terrestrial. Such aquatic orders as Naiadaceæ, Typhaceæ, Sparganiaceæ, Potamogetonaceæ and Aponogetonaceæ are according to the views of the writer undoubtedly primitive. The remarkable male flower of *Naias* in having a terminal stamen, which has either four longitudinal loculi, or one central one, and the female flower with unilocular gynœcium and single erect ovule with pollination under water are no doubt primitive characters. The Butomaceæ and Alismaceæ, as families of the order Helobiales, relate themselves according to some authors with some of the Ranales. And if the Ranales are not highly evolved in structure, having apopetaly and apocarpy, then the Helobic families are comparatively simple for the same reasons.

The families in which the parts of the flowers are surrounded by chaffy scales, namely the Cyperaceæ and the Graminaceæ, are probably not as closely related as was formerly supposed. Some botanists consider that the grass family is to be ranked as a primitive order and not a degraded liliaceous type through the Juncaceæ. This view the author believes is the correct one, and he has, therefore, removed the Juncaceæ from nearness to the Cyperaceæ and placed it as a more primitive form of Liliales with dry, scarious perianth segments. The families with petaloid perianth segments the author has placed on two separate limbs of the family tree. On one limb will be found the families in which the ovary is superior and on the other those families in which the ovary is inferior. Smilaceæ represent the most modified liliaceous type and Juncaceæ the least modified. The Bromeliaceæ, Marantaceæ, Amaryllidaceæ, Orchidaceæ and Iridaceæ, include the most modified types of plants with inferior ovary and are indicated by as many distinct branches of the family tree. Thus from Burmanniaceæ one proceeds to the Orchidaceæ through Apostasiæ and Cypripediæ. The family Dioscoreaceæ includes plants the flowers of which are dioecious forms of amaryllidaceous flowers. Beginning with Musaceæ the series passes through Zingiberaceæ and Cannaceæ to the Marantaceæ, and the botanist finds a strongly marked parallelism of development, the most marked tendency being the petaloid development of the stamens and the style with the reduction of the number of fertile stamens to one.

The Palmaceæ and Araceæ stand off probably, as having affinities with each other, but not closely related to the other petaloideous, monocotyledonous families. Lemnaceæ may be considered to be a modified or degraded form of Araceæ, while the bromeliaceous plants with superior and inferior ovaries show affinities to the Amaryllidaceæ and the Liliaceæ, and hence, the writer has placed the order Bromeliaceæ on a branch near where the two upper limbs of the family tree diverge from each other. The complete liliaceous structure without great reductions in the number of whorls, but with generally few ovules in each loculus of the ovary, is found in the Commelinaceæ, while the Mayacaceæ, as a family, is closely allied to the Commelinaceæ. The Xyridaceæ are marsh plants with radical leaves arranged in two rows and short spikes on long stalks. The flowers, as in Commelinaceæ, have sepals (which, however, are more chaffy) the petals, but the outer series of stamens is wanting. The order Eriocaulonaceæ on another branch is sometimes called the "Compositæ among Monocotyledons" with radical and grass-like leaves, while the habit of the plants of the Restionaceæ is quite similar to the Cyperaceæ.

It is a much more difficult task to trace the affinities of the dicotyledonous families of plants. Roughly we may divide the families into the Incompletæ, the Apopetalæ and the Gamopetalæ. The plants of the primitive Incompletæ are all or nearly all of them provided with flowers that are wind pollinated. Such orders as the Salicaceæ, Myricaceæ, Juglandaceæ, Fagaceæ, Betulaceæ and Corylaceæ are not only wind pollinated, but the staminate flowers are in catkins, thus being advantageously situated for the discharged pollen to be carried away by the wind. The perianth in these orders is absent, or extremely rudimentary. The affinities of these primitive dicotyledons, as the writer has been enabled to determine them, is displayed in the larger of the two accompanying charts.

The apopetalous families in which the petals are absent or distinct are to be regarded as more primitive than the gamopetalous families. The relationship between the families is a group relationship. Thus the Loranthaceæ, Rafflesiaceæ, Balanophoraceæ, Santa-


GAMOPETALAE
Solanaceae
Nolanaceae
Convolvulaceae
Hydrophyllaceae
Polemoniaceae
Convolvulales
Bignoniaceae
Lentibulariaceae
Scrophulariaceae
Lobeliaceae
Campanulaceae
Compositae
Candolleaceae
Goodeniaceae
Myoporaceae
Selaginaceae
Globulariaceae
Cucurbitaceae
Dipsaceae
Valerianaceae
Rubiaceae
Caprifoliaceae
Adoxaceae
GAMOPETALAE
Ericaceae
Pirolaceae
Lennoaceae
Diapensiaceae
Clethraceae
Ericales
Epacridaceae
Acanthaceae
Orobanchaceae
Gesneriaceae
Columelliaceae
Rubiales
Asclepiadaceae
Gentianaceae
Apocynaceae
Oleaceae
Loganiaceae
Burseraceae
Simarubaceae
Anacardiaceae
Meliaceae
Labiatae
Personatae
Verbenaceae
Contortae
Plantaginaceae
Boraginaceae
Cordiaceae
Nuciferae
Rutaceae
Cneoraceae
Zygophyllaceae
Geraniaceae
Oxalidaceae
Tropeolaceae
Linaceae
Aquifoliaceae
Celastraceae
Icacinaceae
Hippocrateaceae
Rhamnaceae
Vitaceae
Aceraceae
Malpighiaceae
Meliantaceae
Sapindaceae
Hippocastanaceae
Staphyleaceae
Tiliaceae
Malvaceae
Sterculiaceae
Cistaceae
Primulaceae
Myrsinaceae
Plumbaginaceae
Primulales
Sapotaceae
Symplocaceae
Styracaceae
Ebenales
Ebenaceae
Ribesiaceae
Saxifagaceae
Hydrangeaceae
Podostemaceae
Hamamelidaceae
Cephalotaceae
Crassulaceae
Platanaceae
Pittosporaceae
Rosaceae
Leguminosae
ANISOCARPEAE
Euphorbiaceae
Callitrichaceae
Buxaceae
Empetraceae
Umbelliferae
Araliaceae
Cornaceae
Violaceae
Koeberlinaceae
Bixaceae
Sarraceniaceae
Nepenthaceae
Frankeniaceae
Tamaricaceae
Elatinaceae
Hypericaceae
Clusiaceae
Theaceae
Dipterocarpaceae
Marcgraviaceae
Ochnaceae
Dilleniaceae
Cistales
Droseraceae
ISOCARPEAE
Rosales
Connaraceae
Cactaceae
Myrtaceae
Melastomaceae
Onagraceae
Myrtales
Hydrocaryaceae
Lythraceae
Haloragidaceae
Rhizophoraceae
Combretaceae
Datiscaceae
Begoniaceae
Caricaceae
Passifloraceae
Loasaceae
Passiflorales
Turneraceae
Malesherbiaceae
Resedaceae
Capparidaceae
Cruciferae
Papaveraceae
Rhoeadales
Fumariaceae
Rafflesiaceae
Balanophoraceae
Loranthaceae
Aristolochiaceae
Santalaceae
Centrospermae
Amaranthaceae
Batidaceae
Chenopodiaceae
Basellaceae
Caryophyllaceae
Phytolaccaceae
Portulacaceae
Polygonaceae
APOPETALAE
Lauraceae
Berberidaceae
Myristicaceae
Menispermaceae
Monimiaceae
Magnoliaceae
Lardizabalaceae
Calycanthaceae
Ranunculaceae
Anonaceae
APOPETALAE
Nymphaeaceae
Ceratophyllaceae
Polycarpicae
Helobiales
DICOTYLEDONS
MONOCOTYLEDONES
CHART DISPLAYING
THE AFFINITIES OF THE
FAMILIES OF THE
DICOTYLEDONOUS PLANTS.
By John W. Harshberger PhD.,
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Philadelphia, Pennsylvania.
April 12, 1907.
Urticaceae
Cannabaceae
Betulaceae
Corylaceae
Fagaceae
Moraceae
Juglandaceae
Myricaceae
WIND
POLLINATED
PLANTS
Ulmaceae
Urticales
Lacistemaceae
Amentales
Salicaceae
Casuarinaceae
Chloranthaceae
Proteaceae
Piperaceae
INCOMPLETAE
Saururaceae
PRIMITIVE STOCK
OF ANGIOSPERMAE

FIG. 2.

laceæ are grouped together not only because of certain structural characters, but because the plants of these orders show a parasitic habit of life. The Portulacaceæ, Phytolaccaceæ, Batidaceæ, Caryophyllaceæ, Amaranthaceæ, Chenopodiaceæ and Basellaceæ form another natural group, while the Cornaceæ, the Araliaceæ and the Umbelliferæ form still another important branch of the dicotyledonous family tree. The families that by the agreement of most botanists form the order of Rhœdales are Resedaceæ, Cruciferæ, Capparidaceæ, Papaveraceæ and Fumariaceæ, while the families that belong to the Ranal Alliance, and are thus suggestive of the Helobial Alliance among monocotyledons, are Ranunculaceæ, Anonaceæ, Magnoliaceæ, Berberidaceæ, Calycanthaceæ, Lauraceæ, etc. The affinity of the families comprising the order, or alliance, Rosales is also very strong. For the other groups and families, the endeavor has been to associate them together in such a manner that the system of branching will suggest the character of the affinity, whether close or distant. Thus the families at the base of any branch are considered in the scheme to be more primitive than those at the extremity of the branch. The arrangement of the lateral branches and their proximity to each other is suggestive of close or distant relationship.

The Gamopetalæ, which are undoubtedly the highest of the angiosperms, naturally group themselves into two main trunks, having both a different phylogenetic origin. The writer has represented these main branches, at the suggestion of Campbell,[1] as Isocarpeæ and Anisocarpeæ. The families included as Isocarpeæ show an ovary that consists of as many carpels as there are petals in the flower, and such families are considered to be more primitive than those of the Anisocarpeæ, where the syncarpous ovary consists of a less number of carpels than there are petals to the flowers. A few of the isocarpous plants have almost distinct petals and to some extent connect the Apopetalæ and the Gamopetalæ. The isocarpous families culminate in the Ericaceæ, Primulaceæ and Styracaceæ. The great majority of the gamopetalous families belong to the anisocarpous division, the less specialized types with regular tubular or funnel-shaped corollas being the morning glories (Convolvulaceæ),

[1] Campbell, D. H., "The Evolution of Plants," p. 213.

phloxes (Polemoniaceæ) and nightshades (Solanaceæ). The anisocarpous families culminate in the order Scrophulariaceæ, Compositæ and Caprifoliaceæ. The composite family is conceded by most botanists to be the most highly evolved and successful type of dicotyledonous plants and is represented in the diagram, therefore, as at the top of the system. It is not only the most successful type, but it is essentially a type of comparatively modern evolution.

It may be said in conclusion that many of the families represented in the chart occupy tentative positions. More thorough work must be done on many plants and plant families before we can feel assured of the true relationship of many of our most widely distributed families of dicotyledonous plants. All attempts at representing the affinities in a diagrammatic way are to be welcomed.